INVESTIGATING THE ROLE OF HYDROGEN IN ULTRANANOCRYSTALLINE DIAMOND THIN FILM GROWTH

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Abstract

A great deal of recent experimental studies and computer simulations have been performed to try to understand the surface stability of diamond nanocrystals. These results have yielded a number of striking conclusions that can help explain the transition of diamond thin film structure from microcrystalline to nanocrystalline with the reduction of hydrogen in the gas phase during microwave plasma enhanced chemical vapor deposition; namely, that the stability of the surface of the diamond nanoparticle is a strong function of both the hydrogen coverage and the size of the crystallite. This study investigates the role of hydrogen in the growth of ultrananocrystalline diamond (UNCD) thin films in two different regimes. First, we add hydrogen to the Ar/CH_4 gas phase during growth, and observe that rather than a monotonic increase in the grain size from the nanocrystalline to the microcrystalline regime, there is an apparent competitive growth process occurring between the two regimes, with the microcrystalline diamond grains becoming much more prominent with added hydrogen. Second, we remove hydrogen from the plasma by changing the hydrocarbon precursor for methane to acetylene and observe that there does seem to be some sort of lower limit to the amount of hydrogen that can sustain ultrananocrystalline diamond growth, below which a significant amount of graphite is nucleated. We speculate the reasons for these observed changes is that large amounts of hydrogen in the plasma favor the rapid growth of diamond microcrystals, while low concentrations of hydrogen result in unstable diamond nanocrystals and the nucleation of graphitic material. This work was supported by the DOE-Office of science-Materials Science under Contract No. W-31-109-ENG-38.

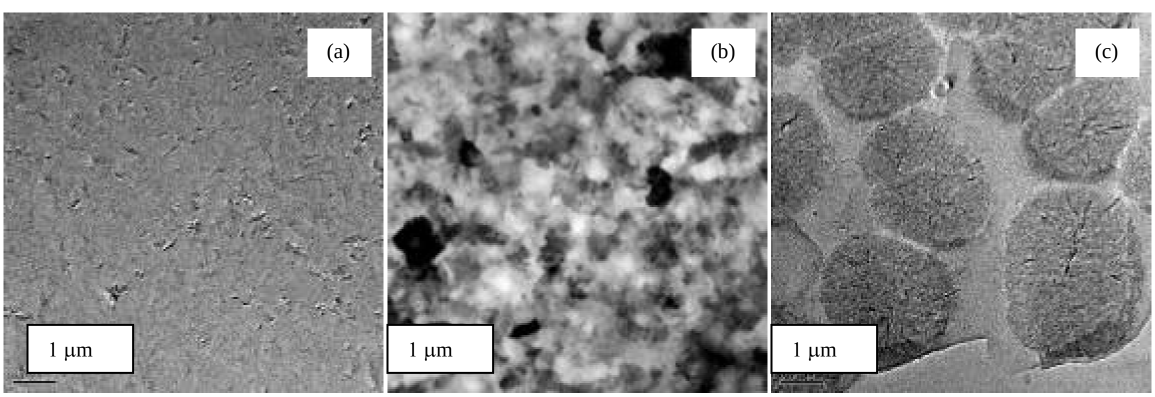

Figure 1: TEM images of UNCD grown using (a) methane and 0% added hydrogen and (b) methane and 20% added hydrogen (c) acetylene and 0.5% added hydrogen.